Volume 5, Number 1, 2014

Innovation Express

Science and Technology News from Agriculture and Agri-Food Canada

Harnessing Genomics to Help Meet Global Food Demand

Genomics, the study of DNA sequences and the functions and complex interactions of genes, is now an important field of research in the agriculture, agri-food and agri-products sector. The knowledge and tools developed through genomics research over the past decade are now helping scientists better understand basic plant and animal functions, find the genes responsible for particular traits, and develop and apply molecular markers. Ultimately, this research will accelerate the development of new germplasm, increase crop yields, and create new products to meet consumer demands.

Globally, most genomics work on crops has targeted just a few major species, particularly corn and soybean. Although Canadian research has focused on our major crops—canola and wheat—an increasing number of plant species are being studied using genomics tools. Today, more than a dozen crop plants grown in Canada have been sequenced. Beef and dairy cattle have also been the focus of significant genomics research.

Over the last decade, the Government of Canada has committed close to $1 billion in funding to Genome Canada to support large-scale genomics research in diverse areas such as agriculture, human health, fisheries and forestry. In addition, from 1999 to 2014, under the Genomics Research and Development Initiative (GRDI), the government will have invested over $353 million in federal laboratories across seven departments and agencies for genomics research.

Agriculture and Agri-Food Canada (AAFC) has participated in the GRDI since its creation and has earmarked its share of the funding for research on sustainable food production, bioproducts, and the management of invasive and quarantine diseases and insect pests.

AAFC has also invested additional funds from its own research budget to enhance collaborations with scientists working with Genome Canada and from the AgriInnovation Program under *Growing Forward 2* to support collaborative work with industry in crop improvement using genomics knowledge and tools.

This is an important time for genomics research, with many opportunities for Canada to excel in the application of genomics within the agriculture, agri-food and agri-products industry. We hope you enjoy reading about some of the genomics projects taking place in AAFC laboratories across Canada in this issue of Innovation Express. Thank you to GRDI for contributing some of these articles.

Dr. Siddika Mithani, Assistant Deputy Minister and
Dr. Gilles Saindon, Associate Assistant Deputy Minister
Science and Technology Branch
Agriculture and Agri-Food Canada

Inside

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Canada

Genomics—A Key to Understanding Fusarium Head Blight

Agriculture and Agri-Food Canada (AAFC) scientists are playing a key part in the international effort to control a growing threat to wheat producers in Canada, the United States and around the world—*Fusarium graminearum*, the causal fungus of fusarium head blight, often referred to simply as FHB. This disease makes wheat unfit for human or animal consumption and is now considered the biggest problem facing Canadian wheat producers.

Over the past 20 years, scientists have focused on developing disease-resistant wheat cultivars; however, now they are tackling the problem from several different angles.

AAFC scientists working in several FHB-related genomics projects funded by the Government of Canada's Genomics Research and Development Initiative (GRDI) have gained insight into how the fungus infects the wheat plant, producing harmful toxins, and helped to identify elements of the wheat genome that play a role in FHB resistance.

Fusarium Gene Library

Research scientists Linda Harris and Thérèse Ouellet and their teams at AAFC's Eastern Cereal and Oilseed Research Centre in Ottawa, Ontario have helped to identify and locate many novel genes that are part of the genome of the causal fungus of FHB. This work has led to the most complete and accurate sequencing of the genome, an essential prerequisite to understanding how the disease infects the plant.

"Back in 1999 when the GRDI funding initiative began, the Fusarium graminearum genome was really a black box—we knew the function of only a very few genes," says Dr. Harris. "We were able to develop a large collection of genes and describe how they operate under a variety of conditions. From there, we were able to contribute to the annotation of the genome sequence, correcting a number of errors produced by automated gene calling done in the past."

Dr. Harris, along with Dr. Gopal Subramaniam and other AAFC colleagues in Ottawa, has also identified specific genes the fungus uses to produce a number of different mycotoxins, and determined when they are produced and under what conditions.

Dr. Harris points out that a lot of work still remains to be done. "Identifying the genes that produce the mycotoxins is just one part of the puzzle," says Dr. Harris. "We also need to identify the genes that tell the mycotoxin-producing genes when to go to work, and what triggers them to give the command."

Identifying Disease-Resistant Wheat Varieties

AAFC scientists are using genomics tools to take some of the guesswork out of wheat breeding and shorten the time needed to develop and test new varieties of FHB-resistant wheat, like AC™ Emerson. This research, initially led by Dr. Daryl Somers at the Cereal Research Centre in Winnipeg, has expanded and is now headed up by Dr. Curt McCartney in Winnipeg and by Dr. Thérèse Ouellet at the Eastern Cereal and Oilseed Research Centre.

From the beginning, the research has focussed on identifying the "genetic markers" of resistance to FHB—indicators pointing to specific parts of the genetic make-up of FHB-resistant varieties that protect against the disease.

This is not an easy task. The wheat genome is exceptionally complex—five times more complicated than the human genome—and it has not yet been fully sequenced. Still, Dr. Somers and his team were able to identify four specific genetic elements that appear to play a role in FHB resistance.

Breeders can now adopt a more logical approach. After two varieties have been crossed, they can look for these markers in the genetic make-up of succeeding generations of plants. If they are not there, they will know there is no point doing any further testing with those particular plants.

"With traditional breeding techniques, you end up wasting a lot of time growing and studying plants that will be susceptible to the disease," says Dr. McCartney. "With marker-assisted

breeding techniques developed through research such as that led by Dr. Somers—the work on which Dr. Ouellet and I are building—you can, at an early stage, identify and discard the plants that are not likely to work, and spend more time studying the plants you are likely to want."

Dr. Ouellet's research is focused on gaining greater insight into the genetic underpinnings of FHB resistance. "Knowing which genetic elements contribute to FHB resistance in the plant is a critical step," says Dr. Ouellet. "But if we can understand how those elements function—which combination of elements in the plant provides the best resistance, for example—we can bring an additional level of strategy to breeding efforts."

The research being carried by Dr. McCartney and Dr. Ouellet, initially funded through GRDI, is now supported by the National Wheat Improvement Program, which is co-funded by AAFC, farmer organizations and private partners in recognition of the value of this research work to the sector.

Dr. Ouellet and Dr. McCartney are quick to share the credit for their achievements with the many other researchers, especially breeders, who have contributed to their projects for a number of years, as well as with their collaborators in Germany, France, the United States and other countries. "This is one of the benefits of GRDI that is sometimes overlooked," says Dr. Ouellet. "GRDI has given Canada the capacity to contribute to advances in genomics around the world—and since we can contribute, we can also share in the advances made by others."

DID YOU KNOW?

- With traditional wheat breeding techniques, it can take up to 15 years to determine if a new variety has commercial potential. The use of winter nurseries and technology such as doubled haploids has reduced this time period down to about eight years. Marker-assisted breeding technology could reduce this process to as little as five years.
- Canada's wheat exports generate close to $5.4 billion in revenue every year, making wheat Canada's most valuable agricultural export.
- The rate of FHB infection continues to rise in Canada and elsewhere. Beyond its impact on the food supply, it is estimated FHB has cost Canadian wheat producers more than $1.5 billion in lost income since the mid-1990s.
- The FHB-resistant winter wheat cultivars, AC Morley and FT Wonder, developed by scientists in Ottawa, have been under commercial production in Eastern Canada for several years.
- Carberry and Waskada, develped by scientists in Swift Current and Winnipeg, are among the first Western Canadian hard red spring wheat varieties with good resistance to FHB.

Dr. Rob Graf and AC Emerson™ winter wheat

Coming Soon: Canada's First Fusarium-Resistant Winter Wheat

A new wheat variety, making its debut next fall, is the first Canadian wheat variety of any type registered and rated "R" (resistant) to fusarium head blight, a fungus that can devastate crops. The new variety, named AC™ Emerson, will be available through Canterra Seeds in 2014.

Dr. Rob Graf and his team at Agriculture and Agri-Food Canada's Lethbridge Research Centre in Alberta developed AC™ Emerson, which is also resistant to stem rust, leaf rust and stripe rust. With good winter survival, moderate maturity, and strong, medium height straw AC™ Emerson also has 1% higher protein concentration and better milling characteristics than the current varieties grown in the prairies.

Registration trials showed that this cultivar is particularly well adapted to the eastern prairie region of Manitoba and eastern Saskatchewan, where its yield was similar to that of the currently predominant varieties, CDC Falcon and CDC Buteo, yielding 100% of CDC Falcon in eastern Saskatchewan and Manitoba. These characteristics are of particular interest to grain growers in Manitoba's Red River Valley, where fusarium head blight is a major concern.

The timing of AC™ Emerson's arrival on the winter wheat scene is also significant for farmers looking to replace CDC Falcon, a long-favoured variety that will be moved to the Canada Western General Purpose "feed and ethanol wheat" class on August 1, 2014.

Dr. Graf is pleased with the attention the new variety is receiving. "Emerson is a great example of the type of research we do at AAFC. It offers the potential for improved food and feed safety, reduced use of foliar fungicides, lower production costs, enhanced market opportunities, and better agricultural sustainability."

DID YOU KNOW?

- AC™ Emerson is joining AC Flourish and AAC Gateway, two other wheat variety replacements for CDC Falcon that Dr. Graf and his team have registered over the past three years.

Canadian Wheat Alliance Strengthening Canada's Wheat Industry

The Canadian Wheat Alliance (CWA) represents an unprecedented long-term commitment by government and industry partners to grow the wheat sector. The partnership between the National Research Council Canada (NRC), Agriculture and Agri-Food Canada (AAFC), the University of Saskatchewan and the Province of Saskatchewan under NRC's flagship research initiative will support and advance research to improve the profitability of the Canadian wheat industry.

Each member brings its own expertise to the CWA for a coordinated approach to improving the quality of wheat and allowing Canada to maintain a competitive advantage in the global marketplace. At present, 86% of the wheat grown on the Canadian prairies comes from varieties developed at AAFC and the University of Saskatchewan.

With $97 million in funding over the first five years of this initiative, the CWA will coordinate research related to wheat breeding, genomics, biotechnology and pathology. This research will help scientists develop new and improved varieties of wheat that are resistant to disease; have increased tolerance to drought, heat and cold stresses; require less nitrogen fertilizer; and produce increased yields.

Wheat is one of the world's most favoured staple foods, second only to rice. As one of the world's primary wheat exporters, Canada needs to significantly increase its production to take advantage of the increased global demand represented by the growing world population and the expected doubling of world wheat trade by 2050. The Canadian Wheat Alliance aims to ensure the global competitiveness of Canadian wheat farmers and to increase the value of wheat at the Canadian farm gate by a cumulative total of $4.5 billion by 2031.

DID YOU KNOW?

- Flaxseeds are not just an excellent plant source of omega-3 fatty acids. The seeds and fibres are used to create many environmentally friendly products.
- Flaxseed oil is a substitute for petroleum-based solvents that is used in a wide range of paints, stains and other coatings. It is also the main raw material of linoleum flooring.
- Flax stem fibres can be used to produce insulation material for houses and car panels. They can also be used to manufacture fire logs and pellets, or bedding material for animals.

Reaping the Benefits of Flax

In the last decade, the popularity of flax as a source of food, animal feed, fibre and biodegradable materials has increased tremendously. Flax has become an important multi-purpose crop that is harvested for its stems as well as its seed. As the largest producer and exporter of flaxseed in the world, Canada has an opportunity to find new markets and new uses for this versatile crop.

Scientists at Agriculture and Agri-Food Canada (AAFC) and the University of Saskatchewan are co-leads in an $11.8 million national genomics project, called Total Utilization Flax GENomics (TUFGEN), which is funded by Genome Canada and industry stakeholders.

According to Dr. Sylvie Cloutier, project co-lead and molecular geneticist at AAFC's Cereal Research Centre in Winnipeg, Manitoba, the project is aimed at developing genomics-based resources to assist in crop breeding, improve field performance and enhance seed and fibre traits so as to ultimately improve and enhance the usefulness, benefits and versatility of flax.

"We have a team of experts across Canada working on various aspects of this project," says Dr. Cloutier. "Some are building resources for gene discovery, developing genetic and physical maps outlining the position and relationship of genes on chromosomes. Others are performing data analysis and management, and developing software systems to preserve and query the new data. Under the TUFGEN umbrella, applied genomics is emphasized and the characterization of lines has received as much attention in the field as in the lab."

TUFGEN team investigators have sequenced the flax genome, the first and only plant genome to be sequenced exclusively by a Canadian team and the twelfth plant genome to be sequenced worldwide. They have since re-sequenced the genomes of more than 700 flax lines.

The team has already created a high density flax gene array that is being used by many international research teams and is in the process of developing new "genotype by sequencing" techniques to rapidly evaluate breeding lines and accelerate breeding gains, particularly for yield.

Dr. Gordon Rowland, project lead from the University of Saskatchewan, explains how the results are being transferred to industry. "The discovery of six new cyclolinopeptides (CLPs) and their corresponding putative gene sequences by TUFGEN scientists has spawned the creation of a new Canadian company, Prairie Tide Chemicals Inc. The company is using these CLPs, known for their immunosuppressive activity, to develop new products for the pharmaceutical industry."

Prairie Tide Chemicals Inc. received over $200,000 in funding from AAFC's Agricultural Innovation Program in March 2013 to recover bioactive peptides and test them for safety of use in pharmaceuticals and nutraceuticals. Over the longer term, the development of safe bioactive peptides could create opportunities in the pharmaceutical sector and help transform a waste by-product into a high-value bioactive ingredient for use in consumer products.

"The time and cost needed to sequence an entire genome is a mere fraction of what it was a decade ago," says Dr. Rowland. "The field of genomics has the potential to propel flax research forward and create opportunities for advancement that were undreamt of only a short while ago."

Mapping of Bean Genome Means New Markets Ahead

Beans are considered the most important food legumes in the world because of their high concentrations of protein, fibre, complex carbohydrates and vitamins. However, for all their nutritional value, very little genomic information is available that could be used to make beans more disease resistant, healthier and more versatile. Scientists with the Applied Bean Genomics and Bioproducts Project www.beangenomics.ca are working to change that and, in the process, they're discovering a wealth of agricultural, health and business opportunities.

This Ontario-based project is a collaborative effort between AAFC scientists (Greenhouse and Processing Crops Research Centre in Harrow; the Southern Crop Protection and Food Research Centre in London, and the Guelph Food Research Centre) and researchers at the University of Guelph, the University of Western Ontario and the University of Windsor. The project is supported by a number of industry partners, including the Ontario Bean Producers, the Ontario Coloured Bean Growers, SeCan and Hensall District Co-operative.

The research team is working to sequence the entire bean genome—something that's never been done before in Canada. The sequence information that is obtained will be used to develop molecular markers for improving disease resistance, enhancing health properties and creating bioproduct applications for dry bean proteins.

Overall, this work will improve producers' profitability by developing more disease resistant bean varieties and thereby reducing crop losses, by developing healthier beans for consumers, and by finding new bioproduct uses for beans.

Common bacterial blight, a major disease of dry beans, can cause yield losses of up to 40%. Sequencing the dry bean genome will enable scientists to develop new tools that can significantly improve the efficiency of plant breeding efforts aimed at developing new bean varieties with improved disease resistance. The use of resistant cultivars is considered the most environmentally friendly approach to controlling plant diseases and is expected to lead to economic benefits for the industry.

Another promising avenue of research focuses on phenylpropanoids—compounds that play a role in many key processes such as plant development and defense and that influence plant qualities such as texture, flavour, colour and processing characteristics. By learning more about the phenylpropanoid pathway in beans, scientists will gain access to many compounds with valuable nutraceutical properties. As beans are naturally low in fat and a source of low glycemic index carbohydrates, increasing the levels of the natural antioxidants in beans would add to their consumer appeal.

Novel bioproduct applications promise to create exciting new opportunities on many levels. Unlike the case for soybean or wheat proteins, the protein-based films that can be developed from different types of beans are not allergenic. What is more, they are biodegradable and can be sustainably sourced from beans culled during bean cleaning operations. Such protein-based films can be used for food packaging that can dissolve in boiling water (e.g., dry soups, sugar, flavour packs), as well as bandaging and capsule manufacturing.

DID YOU KNOW?

- Scientists at AAFC's Research Centre in Harrow have introduced 25 new bean cultivars since the 1980s, helping to diversify bean production in Ontario. This research has helped to open and expand new markets both domestically and internationally.
- Every year, 18 million tonnes of dry beans are produced worldwide, with an estimated economic value of US $11 billion. In Ontario, beans are grown on more than 150,000 acres and are worth approximately $100 million annually.

Soybean Pathogen Breaks Genetic Law

Agriculture and Agri-Food Canada scientists have discovered that a common pathogen of soybeans, *Phytophthora sojae*, which causes soybean root rot, breaks Mendel's Laws of Inheritance.

With funding from the Government of Canada's Genomics Research and Development Initiative (GRDI), an AAFC research team led by Dr. Mark Gijzen made an unusual discovery which has shed light on the pathogen's ability to defeat plant resistance and survive. Virulence traits are passed on, but not through normal Mendelian inheritance, meaning from parent organisms to offspring. The pathogen uses a mechanism called transgenerational gene silencing to pass on traits that enable it to infect and kill soybean plants. A paper highlighting this finding appeared in the scientific journal Nature Communications.

This discovery emerged from research on methods to detect, monitor and control *P. sojae* conducted under a joint initiative between AAFC researchers at the Southern Crop Protection and Food Research Centre in London, Ontario; scientists at Oregon State University; and researchers at Nanjing Agricultural University in China. The ultimate goal is to develop more targeted methods of controlling and managing soybean root rot. Since soybeans are one of the most important food crops in the world and they are very vulnerable to soybean root rot, the benefits of this kind of research will accrue to producers and the soybean industry around the world.

"This is an extremely unusual phenomenon that has never been seen before," says Dr. Gijzen.

"Transgenerational gene silencing is an epigenetic phenomenon, meaning the unit of inheritance is not the DNA sequence of the gene but rather some other self-propagating factor; in this case we believe it to be small RNA molecules. This has big implications that will affect the evolution of this pathogen and how we control it," says Dr. Gijzen.

DID YOU KNOW?

- In Canada, soybeans are grown on 1.5 million hectares in Ontario, Manitoba, Quebec and Prince Edward Island.
- Soybean root rot causes widespread damage amounting to annual production losses of $40 million to $50 million in Canada and $1 billion to $2 billion worldwide.
- Agriculture and Agri-Food Canada has made significant contributions to studying the disease since it was first detected in southern Ontario in the 1950s.

Gijzen's genomics research on the soybean root rot pathogen has also identified many "avirulence factors" in the genomes of specific strains of the pathogen. Avirulence factors are important because soybean resistance genes have learned to use them as cues to activate immune responses that stop the disease—but mutations in these avirulence factors can allow P. sojae to avoid detection by the plant's resistance genes and succeed in infecting the plant.

Based on Dr. Gijzen's findings, a new diagnostic test is expected to be commercially available in the near future, allowing plant breeders to identify at least one strain of *P. sojae* in the soil. Tests to identify additional strains are expected to follow.

"These tests can be done quickly, right in the field, with inexpensive equipment," says Dr. Gijzen. "Knowing which pathogens are in the soil—because we know more about which of the soybean's resistance genes they can attack—growers can plant soybean cultivars with a different set of resistance genes that the pathogen may not be able to attack successfully."

Helping Crops Make Their Own Fertilizer

Finding a way to reduce or eliminate the need for nitrogen fertilizers without reducing agricultural output is the focus of a major global scientific effort.

Dr. Krzysztof Szczyglowski and his team at Agriculture and Agri-Food Canada's Southern Crop Protection and Food Research Centre in London, Ontario are making important contributions to this global undertaking. With funding from the Government of Canada's Genomics Research and Development Initiative (GRDI), they have discovered some of the keys to reducing or eliminating the need for nitrogen fertilizers. Essentially they are striving to unlock the secret behind the ability of some plants to get the nitrogen they need from the air with the aim of transferring this ability to other plants. Their findings have already been published in prestigious journals such as *Nature* and *Science*.

Nitrogen, one of the basic building blocks of life, is a key ingredient in fertilizers, which have played a significant role in increasing crop yields. However, plants fertilized with nitrogen typically use less than half the nitrogen applied to the soil. The excess nitrogen can end up polluting rivers and streams, and nitrogen fertilizers are a significant source of nitrous oxide, a powerful greenhouse gas.

"There are about 380 families of flowering plants on Earth," says Dr. Szczyglowski. "Almost all of them must get the nitrogen they need from the soil. But there are members of about 10 families of plants that are able to get nitrogen from the atmosphere—these are mostly legumes, like peas, soybeans and alfafa."

Dr. Szczyglowski and his colleagues at AAFC, working in collaboration with researchers from Denmark and Japan, have made substantial progress toward increasing understanding of how these plants are able to obtain nitrogen from the air.

"The plants we are studying can't actually do this by themselves," explains Dr. Szczyglowski. "When they sense there is not enough nitrogen in the soil, these plants allow what you might call 'friendly soil bacteria' to enter their root cells. While residing within these cells, bacteria fix atmospheric nitrogen so it can be used by the host plant to support its growth and productivity."

This friendly relationship between the plant and the bacteria is unusual, to say the least, since living cells have elaborate mechanisms designed specifically to keep bacteria out.

The genetic analyses performed by Dr. Szczyglowski and his team have identified parts of the plant's genetic apparatus that act as a sort of command centre. This command centre tells other genes how to act in order to recognize the friendly bacteria, and when and how to let them enter the plant's root cells. Dr. Szczyglowski's team has also identified the gene that initiates a process known as root nodule morphogenesis—essentially, the process by which the root cells change to accommodate the beneficial bacteria.

Perhaps most exciting is the discovery that at least part of the genetic process that allows legumes to interact with bacteria in order to get nitrogen from the air is used by many other plants to interact with beneficial fungi in order to obtain phosphate, another key nutrient.

"Much more work is needed, but this discovery reinforces our belief that it will be possible to transfer the nitrogen-fixing process used by legumes to other important food crops," says Dr. Szczyglowski. "The implications are enormous—developed countries would be able to reduce their use of nitrogen fertilizers, while poorer countries, where farmers cannot afford commercial fertilizer, would be able to increase food production."

DID YOU KNOW?

- The over 7,500 abstracts of the peer-reviewed papers posted on AAFC's website are now linked to the original publications of the scientific journals online.
- You can find a scientist or consult the list of publications (by year) and then open the abstract page by selecting the underlined title of a peer-reviewed publication. From this page, you can select "Access to full text."

DNA Bar Codes Help Tell Friend from Foe

In a project funded by the Government of Canada's Genomics Research and Development Initiative, Agriculture and Agri-Food Canada (AAFC) scientists are using a DNA bar code system to shorten the time it takes to accurately identify invasive pests.

Canadians in many parts of the country have become all too familiar with the damage that invasive alien species can cause. Because these invaders have few or no natural enemies, controlling their spread is extremely difficult and costly. Although the best defence is to stop them at the border, it is not always easy to tell a potentially destructive new arrival from a perfectly harmless native species. In addition to helping to stop the spread of potentially harmful alien species in Canada, the DNA bar code research—led by a team of researchers from different departments—will help to protect Canada's exports.

As Dr. André Lévesque of AAFC's Eastern Cereal and Oilseed Research Centre in Ottawa, Ontario explains, "With this information, we can assure other countries that the products they are buying from us don't contain anything they shouldn't." "We'll be able to quickly identify any organisms or microorganisms that may be present in an export shipment and if they are something that might cause a problem, take steps to manage any risk."

"However, different species of insects, for example, can look remarkably alike. In some cases, there might only be one or two people in the whole country who can look through a microscope and say whether a particular insect spotted on a shipment of fruit from overseas is a foreigner or a native Canadian."

This task is even more challenging when microscopic pathogens are involved. Dr. Lévesque says it can be exceptionally difficult to tell these pathogens apart if all you have to work with are microscopic spores. "It can take days to determine whether a pathogen found in a shipment of perishable goods poses a threat," he says. "Even if the pathogen is found to be harmless, it may be too late to recover any value from the goods."

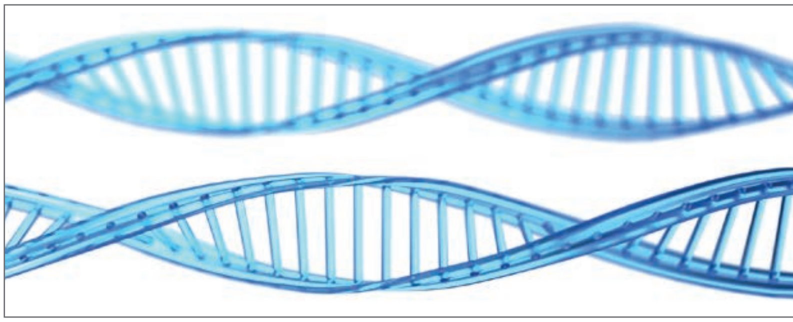
Today, scientists can sequence a specific, small section of DNA from an organism in as little as 24 hours. New technologies on the horizon could reduce the time even further, allowing this kind of sequencing to be done in minutes.

"No two sequences from that part of the genome are the same between most species," says Dr. Lévesque. "So you can read them the same way the scanner in the supermarket reads the bar code on a box of crackers. You feed the sequence into a computer, it compares them to the sequences from known organisms in your database, and within seconds, it tells you exactly what you're dealing with."

Dr. Lévesque says the big challenge at the moment is developing a database that will make these fast comparisons possible. As he points out, "if you have nothing to compare your sample to, it's not going to help you."

In the past, AAFC's biological collections have helped scientists identify invasive species and recommend early control measures, saving farmers millions of dollars. The collections have also been used to help resolve crises related to such pests as potato wart disease, sudden oak disease and Asian soybean rust.

"We have about 20 million specimens—insects, pathogenic fungi, and plants with an impact on agriculture—in our biological collections at AAFC alone," says Dr. Lévesque. "Obviously, we don't have to sequence all of them—we are currently focusing on the high-risk organisms—but along with our colleagues in other departments, Fisheries and Oceans Canada, for example, we are adding many thousands of these DNA bar codes to a database that will be accessible to all agencies within Canada and eventually all over the world."



CORE Investigation of the Oat Genome

Oats are an essential grain for the human diet and for animal feed, and a valuable component in sustainable crop rotation systems. The future of this grain is being transformed thanks to collaborative research at the international level that is improving the genetic map of oat. Agriculture and Agri-Food Canada (AAFC) scientists from across Canada are part of the North American Collaborative Oat Research Enterprise (CORE), which brings together the entire oat research community and stakeholders from Canada, the United States and beyond.

"Having a more complete map of the oat genome will help us access new molecular technologies to develop new oat varieties with better nutritional characteristics that are better adapted to withstand pressure from disease and insect attacks in the field," says Dr. Jennifer Mitchell Fetch, AAFC's oat breeder at the Cereal Research Centre in Winnipeg, Manitoba.

Dr. Nicholas Tinker, a scientist at AAFC's Eastern Cereal and Oilseed Research Centre in Ottawa, Ontario, has played a major role in expanding our knowledge of the oat genome. He previously assembled and analyzed a diverse set of oat germplasm from Australia, Brazil, Canada, Europe and the United States. In the CORE project, he helped to discover and to map thousands of genes and other genetic differences.

"Our global team developed and characterized new genetic markers—a DNA sequence on a specific part of a chromosome that is associated with a particular gene or trait—that have been used to improve the genetic map of oats," says Dr. Tinker. "These markers have provided a solid basis for future efforts in genomic discovery, and comparative mapping. Now, for the first time ever, we have a complete map of the oat genome."

Dr. Tinker's research, funded through the Government of Canada's Genomics Research and Development Initiative (GRDI), has also been instrumental in developing detailed knowledge of the genetic variation in thousands of different oat varieties.

"We have identified genes linked to distinct traits passed on from parents to offspring. This allows us to influence more efficient selection of these traits. More importantly, CORE engaged a dozen excellent oat breeders from around the world. They shared hundreds of oat varieties; they grew them in different environments; we genotyped all of them, and now we all have better tools, germplasm, and knowledge to improve oats. Everyone wins!"

"The work by Dr. Tinker and his colleagues provides new opportunities for directed breeding of superior oat varieties, and guidance for maintaining oat genetic diversity," says Dr. Mitchell Fetch. "It can help me quickly determine if the new oats I am developing have the desired agronomics traits and nutritional characteristics—information that is valuable to both farmers and consumers."

DID YOU KNOW?

- The oat genome has more DNA, and more genes, than the human genome.
- Canada produces 13% of the 22 million tonnes of oats produced globally each year.
- Health Canada has recognized the benefits of oat fibre, supporting the claim that oat fibre helps reduce cholesterol.

Agri-Science Cluster Updates

The AgriInnovation Program, announced under *Growing Forward 2*, includes funding for research clusters and industry-led projects. Research clusters are broad collaborations supporting the highest priority work identified by major sectors and carried out by the best Canadian experts across the country, including AAFC scientists.

For example, a $15 million investment in the Canola Cluster builds on an earlier investment of $14.5 million that laid the groundwork for studying the health benefits of canola oil and new markets for canola meal. AAFC researchers are contributing research on new uses of canola in animal feeds, ways to maximize production and resistance to stresses, strategies for pest management and disease resistance, and improving the economic and environmental sustainability of canola production.

Another example is the recent $12 million investment in the Dairy Cluster that leverages a $6 million investment from the dairy sector and builds on an earlier AAFC investment of $7.2 million that brought together scientific expertise for research in key areas intended to boost the competitiveness of the sector. AAFC scientists will collaborate on several of the industry priorities, including genetic improvement, innovation in sustainable milk production and a better understanding of the link between dairy foods and nutrition. (See the Dairy Cluster website for a list of all dairy-related research in Canada. Project summaries, newsletters and updates are often posted on the websites of the industry partners coordinating the clusters.)

As of January 2014, research clusters have been announced for barley, beef, canola, pulses, dairy, field crops and wheat. All of these clusters build on networks created and research done under the first Growing Forward policy framework, which ended on March 31, 2013. Other clusters are expected to be announced in the coming months.

Tell Us What You Think

Innovation Express is Agriculture and Agri-Food Canada's quarterly news magazine to promote research partnerships and technology transfer to organizations interested in agri-food research and development.

We welcome your comments and suggestions.

Contact us: innovation.express@agr.gc.ca

Electronic Distribution

Our science news magazine is on-line.

www.agr.gc.ca/innovationexpressmagazine

Sign-up for e-mail notification of new issues.

NEW – We're now on Twitter

mobile.twitter.com/AAFC_Canada

Follow AAFC on Twitter for news, interesting facts and links to resources.

Innovation Express

Electronic version available at www.agr.gc.ca/innovationexpressmagazine

ISSN 1920-048X
AAFC No. 10723E

Paru également en français sous le titre *Innovation Express*

For more information, reach us at www.agr.gc.ca.